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**AEROPROJECTS INCORPORATED**

310 EAST ROSEDALE AVENUE, WEST CHESTER, PENNSYLVANIA

July 19, 1962

Interested requesters may  
obtain copies of this  
report from ASTIA.

Bureau of Naval Weapons  
Department of the Navy  
Washington 25, D. C.  
Attention: RRMA-231

Via: Inspector of Naval Material  
10 North 8th Street  
Reading, Pennsylvania

Subject: ULTRASONIC WELDING OF REFRACTORY METALS  
Progress Report No. 8  
For the Period 1 April through 31 May 1962  
Navy Contract No. NOW 61-0410-c

Gentlemen:

As discussed previously\*, our experience indicates that a reasonably practical weld-inspection method for detecting defects is essential to the production of high-quality ultrasonic bonds in refractory-type materials.

In subsequent discussions of these matters at a Bureau of Naval Weapons conference on March 2, 1962, it was agreed that crack formation was a problem encountered in joining the refractory metals by both conventional and ultrasonic welding methods. Moreover, the necessity for developing a reliable, inexpensive, and nondestructive weld-inspection method was accepted as pre-requisite to rapid progress in joining the refractory type materials.

A suitable inspection method should detect unbonded areas, if possible, as well as other defects, and if the bond is unsatisfactory, indicate whether this is due to material damage or some other factor. Thus, weld quality could be maintained by immediately, and possibly even automatically, adjusting the ultrasonic welding machine settings, if necessary, on the basis of the inspection results. Of the various inspection procedures considered to date, however, only an ultrasonic method appears promising at the present time.

Because of the encouraging results with the ultrasonic inspection method reported by Sperry Products, a visit was made to that company. The following was discussed during that visit.

\* "Ultrasonic Welding of Refractory Metals", Progress Report No. 6, March, 1962 and Progress Report No. 7, May, 1962.

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## INSPECTION TECHNIQUES

### SHEAR WAVES

To use shear waves for weld inspection, the specimen thickness, theoretically, would have to be equivalent to at least one wavelength. Consequently, for refractory metals in the gages of interest (0.005 and 0.010 inch) very high frequencies would have to be used. This in turn would produce high "noise" levels, which would interfere with the resolution of weld defects. If the frequency were limited to 5 megacycles, however, the "noise" level would be low and the expected resolution should be good. However, the wavelength at that frequency would be much greater (about 0.060 inch) than the expected thickness of the refractory metal specimens. For this reason, the shear-wave inspection technique was tentatively eliminated from further consideration.

### IMMERSION METHOD (UNDER WATER)

When sound waves are reflected from a metal-water interface, an energy loss of about 12 percent occurs. At a frequency of 5 megacycles, the number of reflections would be very high and the resulting energy loss would be prohibitive. Consequently, further investigation of this inspection method was abandoned.

### SURFACE WAVES

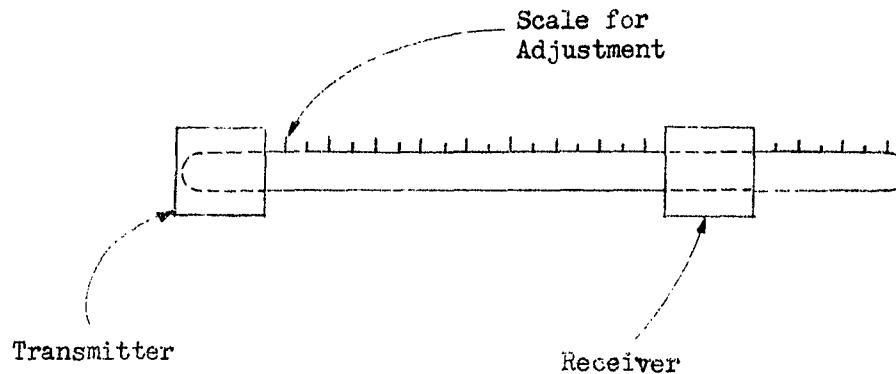
While the limitations of surface waves for weld inspection are similar to those noted for the shear-wave technique, Sperry personnel explained that Lamb waves are also created in material of thin gage and that these waves can be used for crack detection. A limited amount of experimental work, performed during this visit, indicated the feasibility of using the Reflectoscope for two purposes:

Crack Inspection: In this case, a single pulse-echo (transmitter-receiver) transducer would be used. In the absence of internal discontinuities, the normal interface and back reflection of the acoustic energy, supplied by the transducer, is shown by two pips on the oscilloscope screen of the Reflectoscope. A crack would be indicated by an additional pip, which would fall between the other two. With sufficient resolution, both the size and location of the crack can be estimated.

Bond Quality Evaluation: In the transmission method for determining weld quality, two transducers (transmitter and receiver) would be used. The pip size associated with the receiving transducer would be standardized under controlled conditions for a good bond area.

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In the case of a bond area smaller than the one used for standardization, less energy would be transmitted, and consequently, the received pip would be reduced in size. Both the transmitter and receiver must be reasonably well aligned to exercise proper control of the wave propagation direction. Proper alignment can be accomplished by means of the slotted bar device shown in the following sketch.



The adjustment scale on the slotted bar is necessary to compensate for variations in the speed of the Lamb wave propagation, which varies with the frequency and the thickness of the specimen.

#### CONCLUSIONS

The surface-wave inspection method, based on Lamb wave propagation, appears promising for detecting cracks and for evaluating the size of the bonded area. Further development work and extensive evaluation of this inspection technique would be required, however, to demonstrate the validity and practicality of this weld-inspection method.

Very truly yours,

*Harold L. McKaig, Jr.*

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Manager, Advanced Projects

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